THE IMPACT OF TRANSPORT FROM THE SOUTH COAST AIR BASIN ON OZONE LEVELS IN THE SOUTHEAST DESERT AIR BASIN

VOLUME 1 - EXECUTIVE SUMMARY

by

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prepared for

California Air Resources Board

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April 1983

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SUMMARY

An observational program was carried out during July-August 1981 to investigate the impact of transport from the South Coast Air Basin on ozone levels in the Southeast Desert Air Basin. The study was conducted jointly by the California Institute of Technology, Division of Chemistry and Chemical Engineering and Meteorology Research, Inc. The present volume (Vol. I) is an Executive Summary of the program. Vol. Ii gives the detailed results of the study. Vol. III and IV are data volumes prepared by the California Institute of Technology and Meteorology Research, Inc., respectively.

A total of eight tracer releases were carried out by the California Institute of Technology using SF_6 as the tracer material. A total of 34 hourly sampler sites were established for the study. Not all sites were utilized for any given test. Numerous syringe samples were taken during automobile traverses and aircraft flights.

A total of five ozone monitoring stations were established for the duration of the program to supplement the existing ozone network. Aircraft flights were made on each test day by MRI to sample air quality and meteorological parameters. Pibal wind observations were usually made at four locations in support of each test. One of the locations also released an Airsonde at intervals during each test to obtain additional information on vertical temperature structure.

Three tracer releases were made from the western part of the Los Angeles basin (Culver City, Carson and Garden Grove) to document transport into the desert from this area. Two releases were made from the eastern part of the basin (Ontario and South Fontana). One release each was made along the Burbank-Newhall-Palmdale exit route and one in Cajon Pass to investigate transport along these paths. A final release was made at Brawley to examine transport from the Imperial Valley northward into the Coachella Valley.

Tracer trajectories from the western part of the Los Angeles basin followed routes through Soledad Canyon, Cajon Pass, San Gorgonio Pass, up the slopes of the San Gabriel and San Bernardino Mts. and into the Elsinore convergence zone, depending on release location and time of day. Trajectories from the eastern part of the basin and from the immediate pass areas followed expected routes into the desert through the pass and up the mountain slopes. Significant tracer concentrations were observed in the desert from all seven releases made in the Los Angeles basin.

Ozone monitoring data were available during the program from Mt. Wilson, Mt. Baldy, Lake Gregory and Fawnskin (Big Bear). Peak hourly ozone values at Mt. Baldy and Lake Gregory during the field program were the same as Fontana (35 pphm). Maximum observed concentration at Mt. Wilson was 29 pphm. The Fawnskin maximum was only 15 pphm. These data and supportting evidence indicate that a major exit route for pollutants from the Los Angeles basin lies along the slopes of the San Gabriel Mts., through Cajon Pass and extending to the western slopes of the San Bernardino Mts. To the east of Lake Gregory, the transport of pollutants into the San Bernardino Mts. decreases sharply. Other major routes also exist through San Gorgonio Pass and Soledad Canyon. Low-level pollutant transport occurs through the passes and affects the desert areas immediately downwind. In all passes, however, there was evidence of a separate, higher ozone layer moving through the pass which was associated with slope flow along the shoulders of the pass. This upper layer was brought to the surface, on occasion, by lee wave action in the Coachella Valley. On the two observational days in the Mojave Desert, the upper layer remained aloft in spite of strong surface heating.

During the summer months a strong flow of air occurs from the San Joaquin Valley into the western portion of the Mojave Desert, continuing eastward toward Barstow. There is a zone of confluence between this flow and the flow through Soledad Canyon which appears to lie near or slightly north of Edwards AFB on a mean basis. Most frequent wind direction streamlines through Edwards and Barstow suggest an influence from the San Joaquin Valley while Palmdale and Lancaster are most frequently under the influence of the Soledad Canyon flow. Highest ozone concentrations at Edwards AFB, however, appear to be associated with flow from Soledad Canyon which brings air into the desert from areas of large emission sources in Los Angeles County. There was no evidence from ozone concentration, tracer data or wind flow patterns of a Soledad Canyon influence as far north as China Lake.

Carry-over of pollutants in the desert was observed in the form of deep layers of ozone in early morning sampling flights. These layers resulted from transport from the Los Angeles basin during the previous afternoon and evening. On two mornings, peak observed concentrations aloft were 10 pphm or more (Lucerne Valley and Palm Springs). A comparison was made at Palm Springs and Indio of those cases which showed clear evidence of late evening transport from the Los Angeles basin and those where the significance of the transport was much less or non-existent. During the following forenoon the data suggest that the principal effect of the transport was to raise the overall ozone background in the area. The magnitude of the diurnal increase in ozone concentration (from morning minimum to midday maximum) did not apear to be related to the transport of pollutants during the previous evening.

Recommendations include further studies on the effect of slope transport from the Los Angeles basin and the influence of the San Joaquin Valley flow on the Mojave Desert. The importance of the eastern San Gabriel Valley as an early morning reservoir of basin pollutant should also be explored.

1. INTRODUCTION

The Southeast Desert Air Basin (SEDAB) comprises about 33,000 square miles in southeastern California. The western boundary includes the San Jacinto, San Bernardino and San Gabriel Mountains while the eastern boundary generally follows the Colorado River. The area is sparsely populated with an estimated population of about 500,000 as of January 1977 (ARB Staff, 1978). Industrial source emissions are limited and localized. Much of the population resides in the Imperial/Coachella Valley.

In spite of the sparse population of the basin violations of the state ozone standard are observed on a number of occasions during the summer months. Results from several studies have indicated that transport of ozone and/or precursors from the South Coast Air Basin (SCAB) may be responsible for the occurrence of these ozone episodes.

An extensive field study was carried out in July-August 1981 to determine, in more quantitative form, the impact of transport from the South Coast Air Basin on ozone levels in the desert. Specific objectives were taken to be:

1. To document the transport of oxidants and precursors from the SCAB into the SEDAB.

2. To delineate the typical downwind extent of and area of influence of the transport through the various passes.

3. To investigate the relative contribution of local sources and previous day's precursors to the morning oxidant increase in the SEDAB.

In order to carry out the field study a cooperative measurement program was conducted involving the following organizations:

Meteorology Research, Inc. (MRI) - Air quality and meteorological measurements including airborne sampling

California Institute of Technology - Eight extensive tracer tests from various locations in the SCAB and the SEDAB

EPA Environmental Monitoring Systems Laboratory - Airborne downward looking lidar measurements

Jet Propulsion Laboratory - Airborne ozone measurements

California Air Resources Board - Supplementary ozone monitoring stations

Edwards Air Force Base - Supplementary radiosonde observations

The South Coast Air Quality Management District, the San Bernardino County Air Pollution Control District and the Southern California Edison Company provided monitoring data from their own networks.

The final report on the results of the study are contained in a number of volumes. The work carried out by MRI and CalTech is described in four volumes:

Volume 1 - Executive Summary
Volume 2 - Extended Summary and Analyses
Volume 3 - Tracer Data
Volume 4 - Meteorological and Air Quality Data

Portions of the study conducted by EPA and JPL are described in McElroy et al. (1982) and Grant (1981), respectively. A supplementary study to incorporate the results of the remote sensing data (lidar and ozone measurements) with the analyses in the present volume is being carried out by Smith and Edinger and will be completed by late 1983.

2. SCOPE

The field program was carried out from July 9 to August 11, 1981. A total of eight tracer releases were made during this period. Downwind sampling was accomplished with a network of fixed samplers supplemented by mobile traverse teams. Air quality measurements were made by an instrumented light aircraft. Wind and temperature soundings were carried out in support of the tracer releases.

A summary of the various components of the field program follows:

1. Eight SF_6 tracer releases (usually 4 hours duration).

2. Hourly tracer samples (34 locations).

3. Automobile traverse samples (about 1000 or more per test).

4. Aircraft tracer samples (several hundred per test).

5. Winds aloft observation (4 locations per test).

6. Airsonde temperature sounding (one location per test).

7. Aircraft air quality sampling (SO_2, b_{scat}, O_3, NO, NO_x - total of 11 flights, 3-4 hours each).

8. Surface wind data from Mt. Wilson.

9. Ozone and b_{scat} data from Edwards AFB and Mt. Wilson.

10. Ozone data from Mt. Baldy, Desert Center and Iron Mt. (provided by ARB).

11. Ozone data from China Lake (provided by Naval Weapons Center).

12. Upper air soundings (provided by Edwards AFB).

13. Surface wind and air quality data from Lucerne Valley (provided by Southern California Edison Co.).

14. Ozone data from Fawnskin (provided by Cal Trans).

Dr. Williams Grant of the Jet Propulsion Laboratory flew special ozone flights on four days (8 flights) during the program. The Environmental Protection Agency made horizontal traverses over the project area on 10 days (14 flights), providing measurements from a downward - pointing lidar system.

Upper air data from UCLA and Ontario as well as standard surface wind and air quality observations were collected and used in the analysis.

Table 2.1

Summary of Tracer Experiments - 1981

Test	Date	Time		Location
1	July 9	06-10	PDT	Culver City
2	July 14	11-15	PDT	Sylmar
3	July 18	13-17	PDT	Cajon Junction
4	July 22	13-17	PDT	South Fontana
5	July 27	05-09	PDT	Garden Grove
6	July 30	05-09	PDT	Carson
7	August 3	05-09	PDT	Ontario
8	August 11	06-0850	PDT	Brawley

3. METEOROLOGICAL ENVIRONMENT

3.1 General

The Southeast Desert Air Basin (SEDAB) extends from the Mexican border northward into Kern County and eastward from the boundary of the South Coast Air Basin to the California - Arizona border. A map of the area is shown in Figure 3.1.

There are three direct transport routes from the South Coast Air Basin into the SEDAB. These are shown in the figure and include Soledad Canyon, Cajon Pass and San Gorgonio Pass. Transport of pollutants from the South Coast Air Basin into the desert along these routes has been suggested by Trijonis (1973), Lester and Simon (1978), among others, and Drivas and Shair (1974) documented the transport of a tracer gas from Anaheim into the desert. Recently, attention has also been focused on the effects of transport from the San Joaquin Valley over the Tehachapi Mts. into the Mojave Desert (Reible, Ouimette and Shair, 1982).

3.2 Wind Flow Patterns

During the summer months, the wind flow patterns in the South Coast/ Southeast Desert Air Basins are dominated by strong diurnal heating inland and the consequent generation of seabreeze flows. A typical, late afternoon flow pattern is shown in Figure 3.2. The principal features of the pattern are:

1. Flow from the San Joaquin Valley over the Techachapi Mts. into the northern portion of the Mojave Desert.

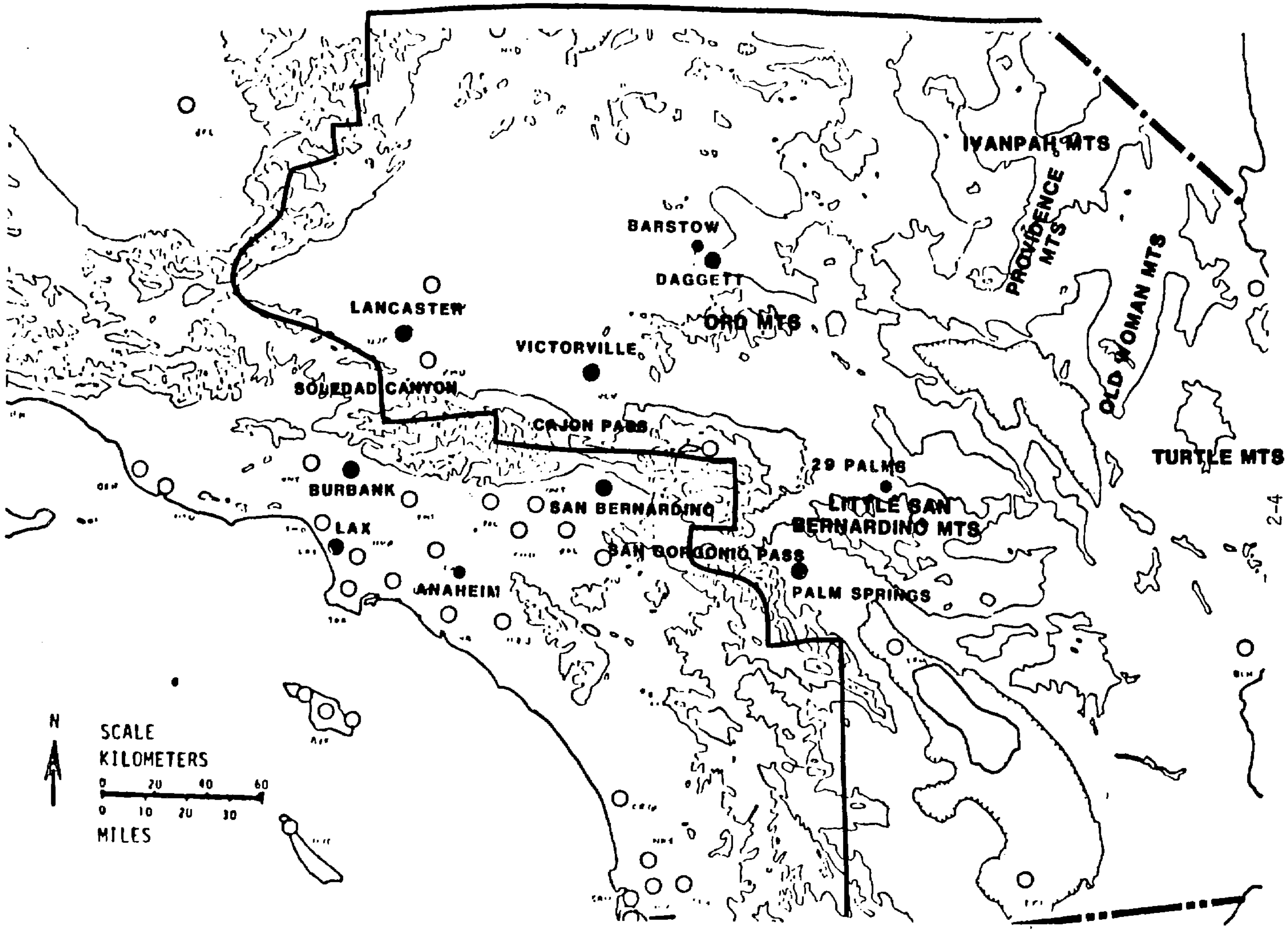
2. Low-level flow through each of the three passes leading out of the South Coast Air Basin (Soledad Canyon, Cajon Pass and San Gorgonio Pass).

3. Upslope flow, particularly along the southern slopes of the San Gabriel and San Bernardino Mts.

4. Convergence zones east of Barstow, south of Riverside and south of Palm Springs.

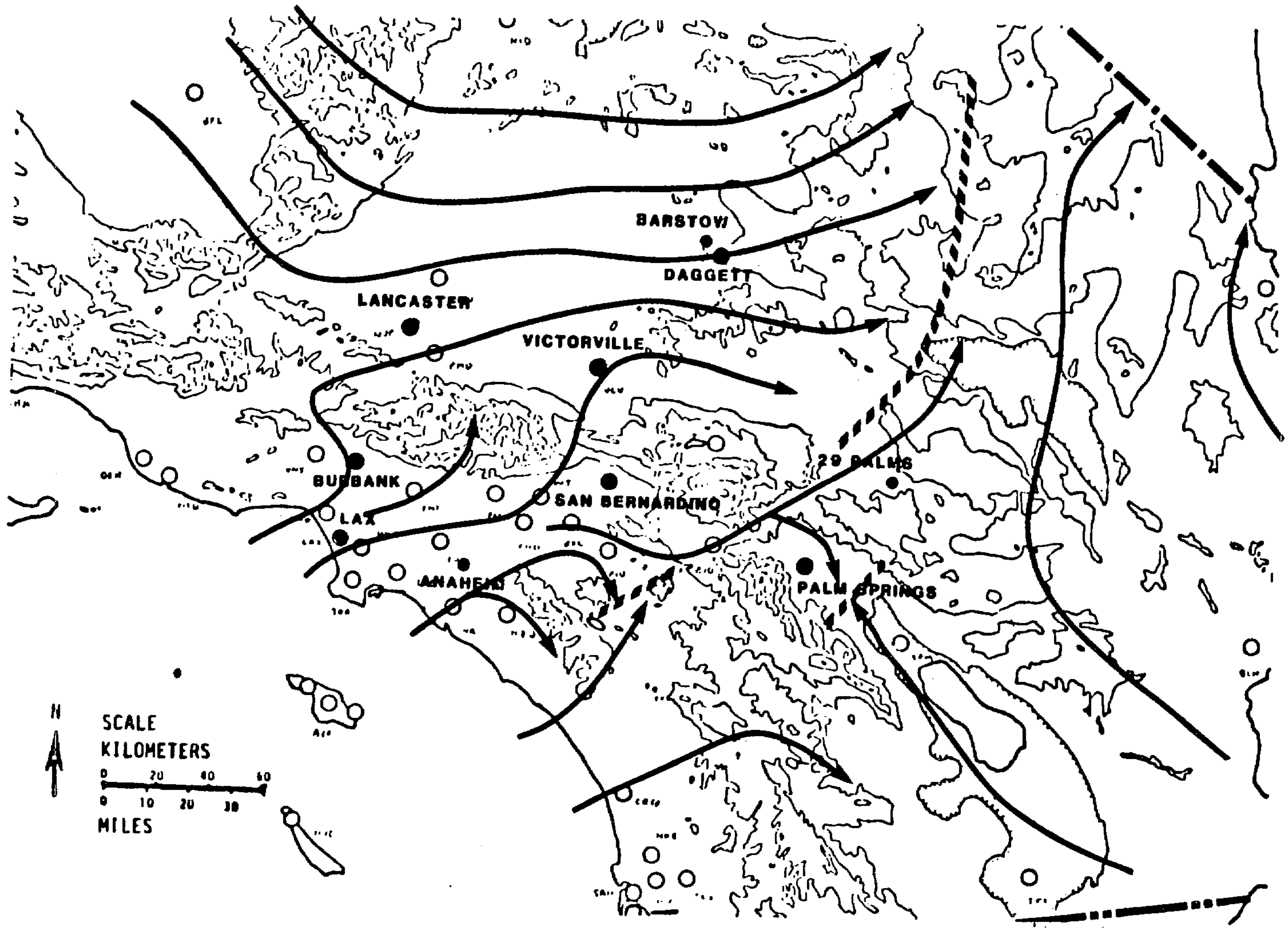
5. Southeasterly flow throughout the southeast portion of SEDAB.

The general topography of the area exerts a major control over the characteristic wind directions associated with the seabreeze. The strength of the flow however, varies with day-to-day changes in the pressure gradients.



MAP OF SOUTHEAST DESERT AIR BASIN

Fig. 3.1



MOST FREQUENT WIND DIRECTION (18 PST) - (JULY - AUGUST)

Fig. 3.2

3.3 1981 Field Program Environment

A measure of the pollution potential in the southern California area can be obtained from an examination of temperatures aloft (e.g. at 850 mb) and coast-to-inland pressure gradients. High temperatures aloft at 850 mb (about 5000 ft) are associated with relatively strong inversions and high pollution potential. Weak pressure gradients result in reduced wind speeds, poor ventilation of the South Coast Air Basin and higher pollution potential within the basin.

The 1981 field study was designed to examine the transport of pollutants from the South Coast Basin into the SEDAB. As a consequence, adequate pressure gradients were required to assure transport into the desert areas. All but one of the tracer tests was carried out under near or above normal pressure gradient conditions for the July-August period. Test 2 was conducted with significantly below normal gradients.

With the exception of Test 7 all tracer tests were conducted under conditions of near or above normal 850 mb temperatures. The tracer test conditions therefore generally represented near or above normal air pollution potential but with sufficient pressure gradients to examine the transport into the desert.

3.4 Air Quality Environment

A number of locations in and near the Southeast Desert Air Basin frequently experience high ozone concentrations during the summer months. Table 3.4.1 shows the maximum ozone concentrations recorded in the five-year period (1977-81) at each of the regular reporting stations and the maximum concentrations experienced during the field program.

Table 3.4.1

Maximum Ozone Concentrations
(1977-81)

Location	Maximum Hourly Ozone	Maximum During 1981 Field Program
Lancaster	27 pphm	21 pphm
Barstow	16 pphm	16 pphm
Victorville	26 pphm	21 pphm
29 Palms (1978-81)	15 pphm	12 pphm
Palm Springs	21 pphm	19 pphm
Indio	19 pphm	18 pphm
El Centro	12 pphm	10 pphm

Lancaster, Victorville and Palm Springs are immediately downwind of the three major transport routes into the desert. Concentrations of 30 pphm or more were observed in the passes themselves (Newhall, Cajon and Banning).

A comparison of the maximum concentrations observed during the field program with the 5-year period indicates that the field period was carried out under representative pollution conditions.

4. TRACER RESULTS

A brief summary of the tracer tests follows:

Test 1 - July 9, 1981 (Release from Culver City - 0600 to 1000 PDT)

The primary tracer plume trajectory was directed to the north-northeast through the eastern part of the San Fernando Valley. The main tracer plume continued past Newhall, through Soledad Canyon, reaching Barstow by 18 PDT. Travel time to Barstow corresponded to an average velocity of about 6 m/s.

The later part of the tracer release was affected by a westerly shift in wind direction with the plume being carried eastward through Azusa and San Bernardino into the Coachella Valley along the eastern shore of the Salton Sea.

Test 2 - July 14, 1981 (Release from Sylmar - 1100 to 1500 PDT)

Principal impacts of the tracer material were observed near Lancaster, at Edwards AFB, at Victorville and at Barstow. From Sylmar to Barstow an average travel velocity of 6 m/s was estimated. The plume trajectory moved through the northeastern San Fernando Valley and Soledad Canyon into the Mojave Desert. The main tracer plume apparently passed to the south of Palmdale and to the north of Victorville.

Test 3 - July 18, 1981 (Release from Cajon Junction - 1300 to 1700 PDT)

During the early portion of the test the tracer plume moved northwestward from Cajon Junction, passing to the west of Victorville and then curved northeastward reaching the Barstow/Daggett area around 22 PDT.

By 16 PDT the wind direction at Victorville had shifted to southwest and the later portion of the tracer plume moved to the east of Victorville, impacting Lucerne Valley by 20 PDT.

Test 4 - July 22, 1981 (Release from South Fontana - 1300 to 1700 PDT)

Pressure gradients from the coast - inland were relatively strong during this test. The primary plume moved through San Gorgonio Pass into the Coachella Valley and eastward through Desert Center. Secondary branches of the plume moved southeastward within the Coachella Valley and northeastward into the Morongo Valley and 29 Palms. Significant concentrations were observed on the following day at Amboy and Blythe. Although there were tracer concentrations observed in the San Bernardino Mts. between Big Bear and Lake Arrowhead, there was no significant transport into the eastern Mojave Desert.

Test 5 - July 27, 1981 (Release from Garden Grove - 0500 to 0900 PDT)

The principal tracer plume moved eastward through Anaheim and Corona, thence southeastward to Elsinore. This portion of the plume is believed to have been introduced into the Elsinore convergence zone and transported aloft.

A later and secondary portion of the plume moved northeastward and was observed during the afternoon at Cajon, San Bernardino and Lake Arrowhead. A portion of this plume moved into the Coachella Valley during the late evening and was observed at Indio.

Test 6 - July 30, 1981 (Release from Carson - 0500 to 0900 PDT)

The main tracer plume initially moved northward into Los Angeles before turning eastward about 12 PDT in response to a shift toward a westerly wind direction. Thereafter, the tracer material moved along the southern edge of the San Bernardino Mts. with one branch going through Cajon Pass to Barstow. A second branch moved through San Gorgonio Pass and into the Coachella Valley as far south as Indio. Travel times to Barstow and Indio represented average wind velocities of about 3 m/s in each case.

Test 7 - August 3, 1981 (Release from Ontario - 0500 to 0900 PDT)

The main tracer plume started, initially, toward the northwest. Observed concentrations near Upland and Ontario were relatively high. Thereafter, the plume direction shifted toward the northeast through Cajon Pass. Small tracer concentrations were observed at Lucerne Valley by mid-afternoon.

Test 8 - August 11, 1981 (Release from Brawley - 0600 to 0850 PDT)

The tracer was released into the southeasterly wind pattern characteristic of the Imperial Valley. The main body of the plume apparently moved northwestward toward Anza/Borrego. A portion of the plume, however, appeared the following morning at Indio.

5. DISCUSSION

Data generated during the field study provided the background information to examine several topics of interest related to pollutant transport into the desert. These topics are discussed briefly below:

5.1 Slope Effects on Ventilation from the South Coast Air Basin

Ozone monitoring during the field program was carried out at Mt. Wilson, Mt. Baldy, Lake Gregory and Fawnskin (Big Bear). Elevations ranged from 4300 to 6800 ft-msl. Peak hourly concentrations recorded at Mt. Baldy and Lake Gregory during the field program were 35 pphm, the same as the maximum recorded at Fontana. Peak values of 29 and 15 pphm were observed at Mt. Wilson and Fawnskin, respectively. Upslope flow, resulting from afternoon heating, transports pollutants upslope from the foothills and provides a significant removal mechanism from the Los Angeles basin. It is apparent from the data collected during the field program that the effective flux of pollutants upslope decreases substantially east of Lake Gregory.

Measurements of the flux of pollutants across the ridgetops at Lake Gregory and Lake Arrowhead showed a shallower layer of pollutants than observed along the upwind slope. At the same time, the wind speeds over the ridge were increased substantially to provide transport continuity.

5.2 Transport through the Passes

Flow through the passes tends to be relatively complex. A low layer of pollutants accompanied by moderate winds is generally present. Frequently a second, separate layer is observed at a higher altitude. This is associated with upslope flow along the shoulders of the pass and generally carries more pollutant loading than the lower layer. In some cases, particularly in San Gorgonio Pass, the complex low-level flow does not transport pollutants effectively through the pass although higher concentrations are observed aloft. The upper layer was brought downward to the surface in the lee of San Gorgonio Pass on several occasions. This was not observed in the lee of Soledad Canyon or Cajon Pass. In the Mojave Desert the low layer was observed to maintain its identity well downwind of the pass with depths of 400-600m.

Times of peak wind velocities and peak ozone concentrations occur successively later along the transport routes from the South Coast Air Basin to the desert. Peak ozone times tend to lead the time of occurrence of peak wind speed by 1-2 hours. This occurrence of successive peaks in ozone and wind speed is strongly suggestive of direct transport from the South Coast Air Basin into the desert.

5.3 Transport through the Desert

Wind energy studies (Berry, Hauser and Lane, 1981) clearly show the importance of flow from the San Joaquin Valley into the western Mojave Desert. Reible, Ouimette and Shair (1982) documented the transport from near Bakersfield into Inyokern. During the summer, this flow continues across the Mojave Desert at all hours of the day, reaching a peak in the late afternoon or early evening. This flow interacts with the flow from Soledad Canyon in a zone of confluence which lies near Edwards AFB, shifting north or south on a day-to-day basis. As a result of these flows the southern portion of the western Mojave Desert is affected primarily by flow from Soledad Canyon while the northern portion is under the influence of San Joaquin Valley flow. No evidence of transport of pollutants or tracer from the South Coast Air Basin into Inyokern was found during the field study period.

In the Coachella Valley, northwesterly winds bring pollutants from San Gorgonio Pass into Palm Springs and Indio and, less frequently, as far south as Thermal. By 24 PDT, northwesterly winds occurred at Palm Springs on 100% of the days during the field period.

5.4 Pollutant Carry-Over in the Desert

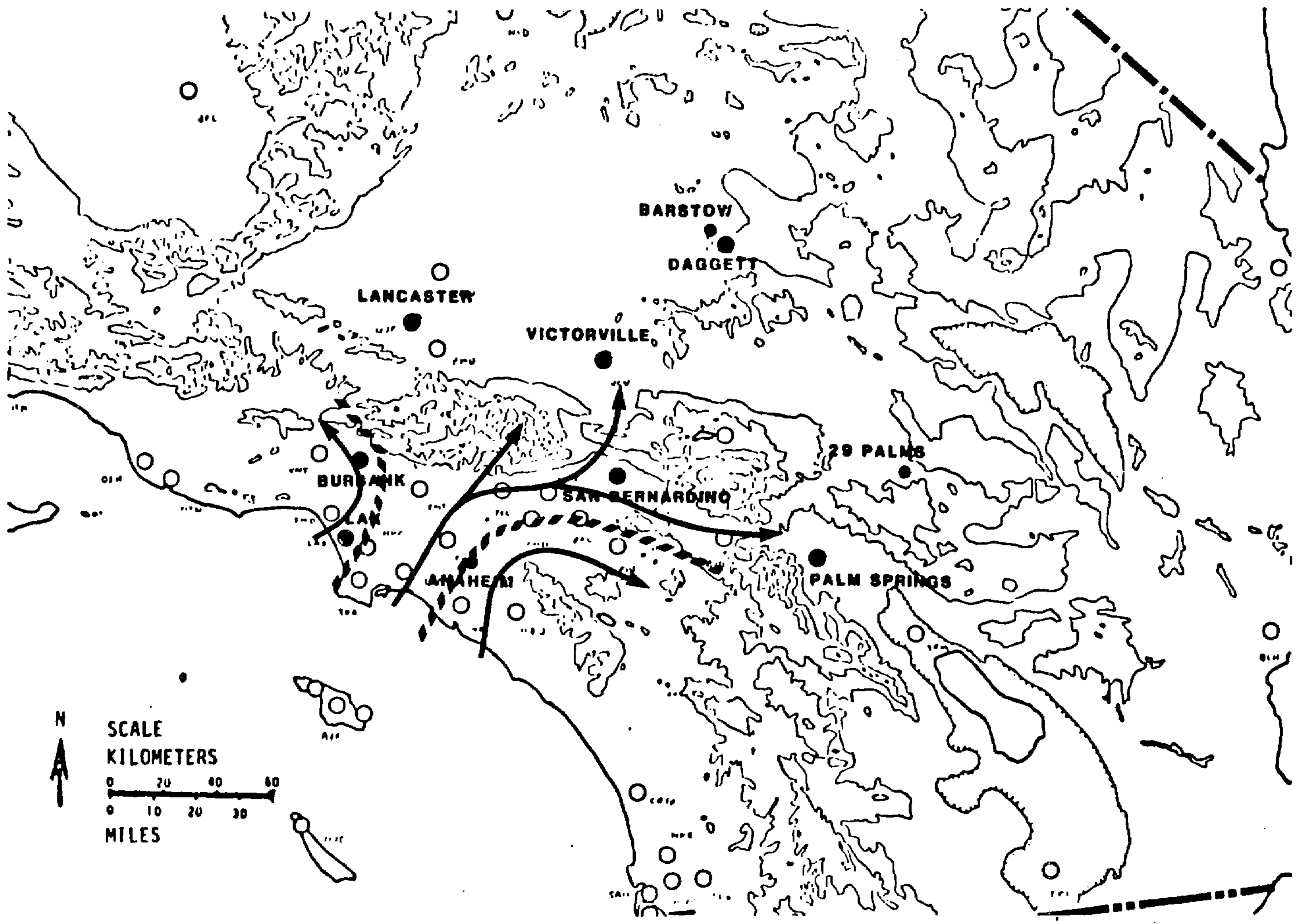
High concentrations of ozone during the morning can be used to indicate carry-over from pollutants previously transported into the desert. During the field program, ozone concentrations of 10 pphm or more occurred at 09 PST on 21% of the days at Lancaster and 13% at Indio and Palm Springs (6% at Victorville). An examination of the ozone concentrations during the day following these occurrences suggested that the principal effect of the carry-over was to provide a higher background in the area. The magnitude of the diurnal increases in ozone during the day at Palm Springs and Indio appeared to be about the same whether the morning ozone concentration was high or not.

Morning aircraft soundings in Lucerne Valley and the Coachella Valley showed layers of ozone to a depth of 700-1200m on all sampled days. On two of the days concentrations aloft were 10-11 pphm and were available to be mixed to the ground later in the day. These layers were attributed to carry-over from the previous day. Carry-over in the Mojave Desert was much less evident, perhaps because of better ventilation of the area during the night.

5.5 Summary of Tracer Results

Concentrations observed from the tracer tests were compared to standard diffusion graphs (e.g. Turner, 1970). The upper bound of all measured concentration data corresponded to stability conditions between C and D according to the Turner scale. These results were independent of the location of the receptor (South Coast Air Basin or desert).

An attempt was made to summarize source-receptor relationships for the South Coast Air Basin based on results of the existing tracer data. An example for morning releases is shown in Figure 5.1. It is indicated in the figure that sources in the northwest of the basin characteristically feed into the flow through Soledad Canyon while releases from southern sources appear to be transported to the south into the Elsinore convegence zone where they may be transported aloft. Releases from a large central portion of the basin are carried eastward and exit the basin through Cajon and San Gorgonio Passes and up the slopes of the mountains.



SCHEMATIC VIEW OF SOURCE AND RECEPTOR LOCATIONS - MORNING RELEASES

Fig. 5.1

6. CONCLUSIONS

1. The northern portion of the Mojave Desert is affected primarily by flow from the San Joaquin Valley. The southern portion is influenced primarily by flow through Soledad Canyon from areas to the south and southwest. The zone of confluence is located in the vicinity of Edwards AFB, shifting north or south on a day-to-day basis.

   The portion of Los Angeles County emissions which feed into the Soledad Canyon flow represents about twice the total emissions of NO_x and THC produced by Kern County. Consequently, the impact of transport from Los Angeles County into the Mojave Desert is significantly greater than the contribution of Kern County.

2. A southeasterly monsoon flow covers the southern and eastern portions of the Southeast Desert Air Basin. This flow dominates the Coachella and Imperial Valleys until late afternoon. The western boundary of the southeasterlies shifts to the east during the late afternoon and evening and moves back westward by the following morning.

3. A strong wind surge from the west and northwest frequently occurs during the night, particularly in the Mojave Desert. Peak velocities are reached around 20-22 PDT with a layer depth of 1500 m or less.

4. Convergent zones occur during the night between the westerly and southeasterly flows, and between separate branches of the sea breeze flow. Convergent areas include the Coachella Valley, Elsinore, El Mirage and the vicinity of the Ord Mts., south of Daggett.

5. Most frequent wind directions for high ozone episodes in the desert indicate a trajectory through the various passes.

6. Backward trajectories from the average time of peak ozone at desert locations indicate a source region in central Los Angeles from Burbank to Anaheim. Two desert areas, (Daggett-Barstow and Edwards AFB), however, suggest trajectories from the San Joaquin Valley on a most frequent basis.

7. High altitude locations in the San Gabriel and western San Bernardino Mts. frequently experience high ozone occurrences. The hourly ozone concentrations during the July-August 1981 field program was 35 pphm at Mt. Baldy, Lake Gregory and Fontana. Mt. Wilson experienced a peak value of 29 pphm.

8. A significant portion of the basin air exits through the region from Mt. Baldy to Lake Gregory. The pollutant flux decreases sharply to the east of Lake Gregory but increases again through San Gorgonio Pass. Peak hourly ozone occurrence at Fawnskin was 15 pphm during the field program. The Santa Ana River Canyon was not a major exit region for pollutants on the two days when sampling took place in the area.

9. Ozone concentrations at Mt. Baldy and Lake Gregory frequently showed a midday peak value associated with local pollutant sources in the eastern San Gabriel Valley as well as an afternoon peak which was related to transport from the central Los Angeles area.

10. In each of the three major passes there was evidence of two or more layers of ozone being transported into the desert. The lower layer consisted of direct transport through the low levels of the pass. The upper layer was associated with up slope flow along the shoulders of the pass which delivered pollutants to a level where they could be transported through the upper portion of the pass. This, in effect, substantially increased the transport through the pass region.

11. Downwind of San Gorgonio Pass the upper layer was brought to the surface, on occasion, by the effects of lee wave action on the desert side of the pass. This led to higher ozone concentrations in the desert than were observed in the pass at Banning. Downwind of Soledad Canyon and Cajon Pass the upper layer continued aloft across the desert without surfacing on those days when observations were made.

12. On each of four mornings when aircraft flights were made in the desert, relatively deep layers (700 to 1200 m) of ozone were observed, particularly in the Coachella and Lucerne Valley areas. Peak ozone concentrations were 10-11 pphm on two of the days. These layers were associated with transport into the area during the previous afternoon and evening.

13. Total NO_x loadings as measured by morning aircraft spirals in the desert were comparable to those in the Los Angeles basin. Afternoon loadings were highest in the basin and in the immediate vicinity of the passes. These data provide another indication of transport and carry over into the desert areas.

14. On 10-15% of the days during the field program high ozone concentrations (10 pphm or more) were present at 09 PST at Indio and Palm Springs. These high concentrations were associated with transport from the Los Angeles basin. Diurnal ozone increases on these days, however, were similar to observed increases on days with low morning concentrations. It is suggested that the principal effect of the carry over is to provide a high background level of ozone rather than to provide additional precursors.

15. Morning visibility restrictions observed in the Coachella Valley are generally associated with transport from the Los Angeles basin but evidence of local contributions is apparent. Local sources are the primary contribution to restriction in the Imperial Valley.

16. Tracer trajectories carried SF_6 material along the San Fernando-Newhall-Lancaster route, through Cajon Pass and San Gorgonio Pass, up the slopes of the San Gabriel and San Bernardino Mts. and into the Elsinore convergence zone, depending on release location and time. Primary tracer impacts in the desert from Los Angeles basin releases were found at Palmdale, Victorville, and Indio. Smaller impacts were noted as far as Barstow, Amboy, Blythe and Bombay Beach. There was no evidence of tracer impact at China Lake from any of the releases in spite of extensive sampling at that location.

17. Similarities in tracer trajectory routes led to a schematic perspective in which source regions in the northwest fed into Soledad Canyon, regions in the south fed into the Elsinore convergence zone and, in the central zone, sources fed into Cajon and San Gorgonio Passes as well as the San Gabriel/San Bernardino Mts. slopes. The boundaries of the zones shift somewhat from day-to-day and diurnally.

18. Maximum observed tracer impacts from Culver City were comparable at Palmdale and Indio. From Carson the maximum impacts were similar at Victorville and Palm Springs.

19. An area of anomalous SF_6 concentrations was observed on a number of occasions between Pasadena and Pomona. Further investigation is recommended before additional tracer studies are made near the mountain slopes.

7. RECOMMENDATIONS

1. It has been determined from the present program and from previous studies that slope flow along the San Gabriel and San Bernardino Mts. provides a significant mechanism for removal of pollutants from the Los Angeles basin. There is, however, considerable variation along the ridge line with a major contribution observed in layers within an extended crossection of Cajon Pass. Because of this east-west variation in effectiveness it is difficult to quantify the total pollutant burden exiting from the basin along this route. In addition, the fate of the upslope pollutants is not clear. There is considerable evidence that they form a layer aloft (subject to upper level wind direction) which may or may not subsequently contribute to ground concentrations elsewhere. Additional studies of this mechanism would aid in the development of more realistic modeling of the basin and would determine whether significant downwind impacts could be associated with the effects of the upslope flow.

2. The relative contribution of the Los Angeles basin and the San Joaquin Valley to pollutants in the Mojave Desert is a matter of considerable interest. Evidence suggests that the northern part of the desert is influenced by the San Joaquin Valley and the southern part by the Los Angeles basin. Through the use of aircraft and pibal soundings, pollutant flux calculations could be made along a vertical plane (e.g. from south of Palmdale to north of Mojave). These would permit delineation of the effects of the two flows and permit the requirements for upwind control to be better evaluated.

3. The eastern San Gabriel Valley (Pomona - San Bernardino - Riverside) appears to be a light-wind reservoir where late afternoon pollutants from Los Angeles can reside overnight and combine with local pollutants to produce significant local contributions during the following morning. These affect the mountain slopes as well as the eastern basin. Under some episode conditions, the residence time of pollutants in the area may be longer than one 24-hour period. With the forecasts of rapid population growth in the area, the ventilation of the eastern basin under episode conditions should be examined.

4. The hypothesis was advanced in this study that carry-over of pollutants in the Coachella Valley contributes to the background ozone level but that the reactive component of these pollutants did not seem to contribute greatly to local concentrations. This could easily be checked by reactive hydrocarbon measurements in the Palm Springs - Indio area under a range of morning background ozone levels.

5. Suggestive indications of transport from the Imperial Valley into the Coachella Valley were obtained during this study. A more serious study could evaluate the extent of this contribution from the Imperial Valley.

6. A number of apparently extraneous SF_6 concentrations were observed in the eastern San Gabriel Valley during the field program. Although they did not create a major problem for the present study, they may limit the usefulness of tracer techniques in certain areas of the basin. A few mobile surveys of the area might be able to define the extent of the potential problem.

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